price of timber and the high rent at present obtained by the letting of grouse moors and deer forests.

Upon data which cannot be gainsaid, Dr. Schlich has based important calculations, which will be found on pp. 17–19. Space forbids the discussion of details, but the result is that Scotch pine forests cannot be expected to yield more than 2½ per cent. on the capital invested (the value of the land and of the growing crop).

> "All land, therefore, which can be let for the raising of field crops, for shooting, or other purposes, at a rental equal to, or upwards of, 2½ per cent. of the capital value of the land, had better be so let. On the other hand, land which would realize a rental of less than 2½ per cent. of its value, may with advantage be planted with Scotch pine or other similarly remunerative trees."

These conclusions are based upon circumstances as they exist at the present time. But a change of circumstances is not impossible. The author points out that 6,000,000 loads of timber are imported annually into the United Kingdom from Europe and North America, and that only a small portion of the forests which furnish this large supply are under systematic management and control. It may be regarded as certain that the supply from Sweden and Norway and from North America, amounting at present to nearly 4,000,000 loads a year, will continue to diminish, and, under the circumstances of the case, the necessary result of such diminution will eventually be a rise in the price of timber. Again, if proprietors of woodlands in England and Scotland were in a position to offer large quantities of home-grown timber of good quality for sale, regularly at stated seasons, timber traders would make their arrangements accordingly, and in many cases better prices would be obtained. Firewood is at present almost unsaleable in the United Kingdom, but if—and this may happen—the price of coal should rise considerably, firewood would in some districts become an article of general consumption, as it was 150 years ago, and to some extent this would improve the money yield of woodlands.

It is not too much to say that the publication of Dr. Schlich's manual will give a powerful impetus to systematic forest management in the United Kingdom, in India, and in the vast colonies of the British Empire—in fact, wherever the English language is spoken.

D. BRANDIS.

FERREL'S THEORY OF THE WINDS.

A Popular Treatise on the Winds. Comprising the General Motions of the Atmosphere, Monsoons, Cyclones, Tornadoes, Waterspouts, Hailstorms, &c. By William Ferrel, M.A., Ph.D., &c. (New York: John Wiley and Sons. London: Macmillan and Co. 1889.)

NUMEROUS as are the popular treatises on various branches of phenomenal meteorology that have appeared during the last quarter of a century, English literature has hitherto been singularly deficient in elementary works treating of the physical and mechanical processes of the atmosphere from a theoretical point of view, and suited to the capacity of the average student. Those versed in the higher mathematics may indeed find all they require in such modern works as Sprung's "Lehrbuch der Meteorologie," and Ferrel's "Recent Advances in Meteorology," the high merit and originality of which last are somewhat veiled under its more obtrusive title—"Part 2 of the Report of the Chief Signal Officer of the [U.S.] Army for 1885." But these works are hardly suited for popular instruction; and for that large class of students whose mathematical acquirements are more limited, but who nevertheless desire to understand the movements and internal changes of the atmosphere, and to interpret them rationally in accordance with mechanical and physical laws, there has hitherto been little guidance, save such as they may obtain from casual references to them in works devoted to the general teaching of these sciences. It is perhaps in consequence of this divorce of the deductive from the inductive treatment of meteorological subjects that the contributions of English observers to the science of meteorology bear but an insignificant proportion to the labour expended on observational work, and that so much of this work is abortive, and practically of little value, owing to the absence of guiding and suggestive theoretical knowledge.

It is, then, with no ordinary degree of satisfaction that we hail the publication of Prof. Ferrel's treatise, the title of which heads this notice. As the originator and discoverer of many of the most important problems dealt with in these pages, no one could be better fitted to explain them in terms suited to general comprehension, and this task he has performed with a completeness and lucidity which leave but little to be desired. The work is, as it professes to be, a "popular" treatise, but popular only in the higher sense of the word. A system of movements so complex as those of the earth's atmosphere cannot be made clear to anyone who is not capable of following a chain of close reasoning, or who is not prepared to bring to the study that concentrated attention that is requisite to master any problem in deductive science. But, these being granted, no further demand is made on the student than some familiarity with the elements of algebra, and the simplest conceptions of plane trigonometry and kinetics. The action of the mechanical and physical forces that determine and regulate the wind system of the globe is clearly explained in the first two chapters of the work.

The most important and original portion of the book is that which deals with the general circulation of the atmosphere, in relation to which the cyclones and anticyclones that cause the vicissitudes of local weather are but matters of subordinate detail. The magnitude of the work achieved by Prof. Ferrel in this field has hitherto been recognized only by the few. It is not too much to say that he has done for the theory of atmospheric circulation that which Young and Fresnel did for the theory of light; and that the influence of his work is not more generally reflected in the literature of the day, must be attributed to the want of some popular exposition of the theory.

Starting with the fundamental conditions of a great temperature difference between equatorial and polar regions and a rotating globe, and postulating in the first instance a uniform land or water surface, it is shown how the convective interchange of air set up by the former must result in producing two zones of maximum pressure in about lat. 30° in both hemispheres, two principal minima at the poles, and a minor depression on the equator, together with strong west winds in middle and high latitudes, and an excess of easterly winds in equatorial regions. The two tropical zones of high pressure determine the polar limits of the trade winds, and the whole system oscillates in latitude with the changing declination of the sun. Further, as a consequence of the fact that the great mass of the land is restricted to the northern hemisphere, whereas the southern hemisphere presents a comparatively uninterrupted sea surface, on which the retarding friction is less than in the northern hemisphere, the west winds of middle and high latitudes are much stronger in the latter than in the former, and by their lateral pressure cause a slight displacement of the tropical zones of high pressure and the equatorial zone of low pressure to the north of their normal positions on a hypothetical uniform terrestrial surface.

The great modification and extension of Hadley's theory thus introduced by Prof. Ferrel depends mainly on two points of the first importance. By all previous writers it was assumed that a mass of air at rest relatively to the earth's surface on the equator, if suddenly transferred to some higher latitude—say, *e.g.*, 60°—would have a relative easterly movement in that latitude equal to the difference of rotary velocities on the equator and on the 60th parallel, or about 500 miles an hour, the difference being proportional to that of the cosines of the latitudes. This, however, would be true only in the case of rectilinear motion. In reality, as Prof. Ferrel was the first to demonstrate, the mass of air would obey the law of the preservation of areas, like all bodies revolving under the influence of a central force, and its relative eastward velocity in latitude 60° would be 1500 miles an hour, being as the difference of the squares of the cosines. If, on the other hand, any mass of air at rest in latitude 60° were suddenly transferred to the equator, it would have a relative westerly movement of 750 miles an hour, and any mass of matter whatever moving along a meridian is either deflected—or if, like a railway train or a river between high banks, it is not free to yield to the deflecting force, presses—to the right of its path in the northern, and to the left in the southern, hemisphere.

The second point first established by Prof. Ferrel is that, in virtue of centrifugal force, this deflection or pressure to the right in the northern, and to the left in the southern, hemisphere is suffered in exactly the same degree by bodies moving due east and due west, or along a parallel of latitude, and therefore also in all intermediate azimuths.

From the first of these principles it will be readily seen why the west winds of middle latitudes are so much stronger than the easterly winds of the equatorial zone; and from the second, how these opposite winds, by their mutual pressure, produce the tropical zones of high barometer and the polar and equatorial regions of low barometer.

In subsequent chapters are discussed the modes in which the general circulation of the globe affects the climates of different latitudes by determining the distribution of rainfall in wet and dry zones, and inequalities of temperature through the agency of marine currents. Also the causes that modify and disturb the regularity of the ideal system, the chief of which is the mutual interaction of expanses of land and sea. The general excellence of these demonstrations is indisputable, but we have marked one or two passages which appear to us to be of doubtful validity, and which we recommend to the reconsideration of the author when the time comes, as we doubt not it will ere long, for the issue of a second edition of his work.

The first point to which we would take exception is what seems to us the too great influence ascribed to mountain-chains in deflecting the great atmospheric currents. That they deflect the surface winds, like other irregularities of the surface, and in proportion to their magnitude, is, of course, a matter of universal experience; but, in the absence of other causes operating to produce a diversion of the greater currents, their action in this respect appears to us to be merely local. As an instance we will take the case of the Western Ghats of India, an escarpment from 3000 to 7000 feet in height, running athwart the direction of the summer monsoon of the Arabian Sea. The wind charts of the Arabian Sea, issued by the Indian Meteorological Office, show no appreciable deflection of the monsoon wind on the windward face of this range; and if the same cannot be asserted of the corresponding wind in the north of the Bay of Bengal, where it impinges on the coast range of Arakan, it is evident that the deflection of this current to north, and eventually to north-west, is caused by the indraught towards the heated plains of Northern India.

We believe that a similar explanation will be found to hold good in all the more conspicuous cases cited by Prof. Ferrel. Thus, at p. 183 he says:—

> "The air of the lower strata of the atmosphere in the trade-wind zone of the North Atlantic, having a westerly motion, and impinging against the high table-lands and mountain-ranges of Mexico, is deflected around towards the north over the south-eastern States, and up the Mississippi valley into the higher latitudes, where it combines with the general easterly flow of these latitudes, and adds to its strength. This completely breaks up the continuity of the tropical calm belt and dry zone, so that, instead of a dry region with scanty rainfall, such as is found in North Africa, Arabia, Persia, Beloochistan, and Cabul, we have on the same parallels in the southern and eastern United States a region of abundant rainfall, and all the way up the Mississippi valley and in the interior of the continent there is much more rain than in the interior of Asia."

Taking this passage as it stands, or only together with the immediate context, it might be understood to imply that the author ascribes this great diversion of the winds of the Gulf of Mexico, together with all the rainfall they bring to the southern States of America, solely to the influence of the comparatively low mountain-chain of Central America. That such, however, is not his meaning is evident from his subsequent remarks on p. 215, where, in describing the monsoons of North America, after noticing the high temperature of the land area in summer, he says:—

> "On the southern and south-eastern coast, in connection with the deflection referred to [in the passage quoted above], it causes the prevailing winds to be southerly and south-easterly, instead of north easterly, as they would otherwise be in these trade-wind latitudes."

In point of fact, as may be seen on Dr. Hann's charts for January and July, in the new edition of Berghaus's "Physical Atlas," the diversion of the trade-winds of the Gulf of Mexico, northward up the Mississippi valley takes place only in the summer, and is an effect of the same agency, viz. the heating of the northern continents, that breaks up the high-pressure zone of the northern tropic into two anticyclones, one in each of the great oceans, and it is the juxtaposition of the Atlantic anticyclone and the Mexican cyclonic depression that determines the course of the winds and the resulting rainfall. To judge from the case of the Western Ghats, we think it may be safely concluded that, if there were no mountain-chain to the west of the Gulf, the results would not be greatly different. All the other instances quoted, illustrative of the diversion of great currents by mountain-chains, except such as are purely local, appear to us to be really due to other and similar causes.

In treating of the monsoons, Prof. Ferrel points out with perfect justice that their strength depends on the form of the land, and that they blow strongly only where the interior of the country is high and mountainous. But when he adduces Persia as an illustration of the negative case, we are unable to admit its relevancy. At p. 199 he observes:—

> "In accordance with the preceding view of the principal cause of monsoons and land and sea breezes, it is seen from observation that all the great monsoons and the strongest land and sea breezes are found—the former in countries and on oceans adjacent to high mountain-ranges, and the latter along coasts with high mountains in the background. Neither the heated interior in summer of the Great Sahara of Northern Africa, nor of Arabia and Persia, which is considered the warmest region on the globe, causes, during this season of the year, any great indraught of air. It is true that at this season the north-westerly winds prevail a little more on the north-west coast of Africa and the ocean adjacent, due, no doubt, to the influence of the highly-heated desert of the Sahara; but over Arabia and Persia the north-west winds continue to blow almost incessantly, during June and July, away from the interior toward the Arabian Sea. . . . The monsoon influence, therefore, of countries mostly level, without an elevated interior, however highly they may become heated in summer or cooled in winter, is not very great."

But the interior of Persia is a part of the great table-land of Iran, and, to quote the description of Sir Oliver St. John, "its average height above the sea may be about 4000 feet, varying from 8000 or higher in certain of the outer valleys to not more than 500 in the most depressed portions of its centre." Its average elevation is therefore much greater than that of the interior of India, very much greater than that of the Indo-Gangetic plain, which is the goal of the Indian monsoon, and, as a glance at the map will show, it is not deficient in mountains. The explanation of the fact that, instead of attracting the monsoon from the Arabian Sea, it is itself swept by north-west and west winds—blowing, not, indeed, towards the Arabian Sea, but towards the lower Indus valley—must then be sought for elsewhere. The true explanation appears to us to lie in a combination of causes. Partly, perhaps, in the latitude, which brings it within the zone of the strong easterly current of extra-tropical regions, which, by its right-handed pressure, must resist any indraught from the Arabian Sea; but chiefly in the fact that any tendency that the heated highlands of Persia may have to create such an indraught is overborne by the stronger set towards India. For the latter country reaches far down into the tropics, and the centre towards which the monsoon blows must be determined by the resultant of all the temperature gradients of the whole heated region. An eastward direction having been given to the monsoon at the outset, its strength in that direction is greatly increased by the energy set free in the Indian monsoon rainfall.

This question is one of more than theoretical importance. These west winds of Persia and Afghanistan are the dry winds of Northern and Western India, and when they prevail beyond their normal limits, over the north of the Arabian Sea and a great part of India itself, to the exclusion of the rain-bearing current, they bring the drought and consequent dearth that have made India so disastrously notorious for its famines. Possibly, the explanation of their abnormal extension may be looked for in those oscillations of the great polar cyclonic systems to which Prof. Ferrel alludes at p. 339 of his work.

Cyclones and tornadoes are treated at great length, each of these subjects occupying more than one hundred pages of the book; and in connection with the latter is given the author's theory of the formation of hail, a subject which has hitherto been less understood than almost any other phenomenon of the atmosphere. It will be best given in the author's own words:—

> "In the ascending current of a tornado, as in that of the equatorial calm belt, or of a cyclone, the rain-drops are formed down in the cloud region, and carried upward until they become too large to be supported by the current and so fall to the earth. . . . In a tornado, however, the ascending current is often so strong that the rain is supported until, by the blending of the small drops by coming in contact, very large drops are formed, and the strong ascending currents often extend so high that these large drops are carried away up into the region of freezing temperature. . . . There they are frozen, and after having been carried up and outward above to a distance from the centre, where the ascending current is not strong enough . . . to keep them up, they slowly descend, and receiving additions of ice as they fall, as long as their temperature remains below zero, . . . they finally fall to the earth as solid hailstones"

The concentric coatings so commonly observed in large hailstones are explained by these hailstones being carried again and again into the vortex by the strong indraught in the lower part of the storm-cloud, the theory being that every hail-cloud is a tornado, although it may not reach down to the lower atmosphere. The vapour being condensed as water in the lower part of the vortex, which is frozen at a higher level, and as snow in the upper part, each pair of coatings indicate an additional ascent through the storm-cloud. This view, which, even at first sight, seems far more reasonable than any previous theory, has received unexpected confirmation from the experience of more than one adventurous balloonist, more especially that of Mr. John Wise, whose fate it was to be drawn seven times successively into the vortex of a hail-cloud, and carried up repeatedly until the balloon was thrown out at the top. The account is, unfortunately, too long for extracting.

From what has been said, it will be apparent that Prof. Ferrel's book enters very fully into the many important topics enumerated in the title. Indeed, its subject-matter covers very much of the ground of which modern meteorology usually takes cognizance, and in the thoroughness of its treatment we know of no modern work in our language that can be brought into comparison with it.

H. F. B.

A NEW ATLAS OF ALGÆ.

Atlas deutscher Meeresalgen. Heft I. Von Dr. J. Reinke (Berlin: Paul Parey, 1889).

THE German Government, operating through the Kommission zur wissenschaftlichen Untersuchung der deutschen Meere, has undertaken to bear the cost of producing this sumptuous "Atlas" in the interests of fishery, and students of phycology have to thank an economic aspect of their study for a very remarkable addition to the literature of it. Similarly, we are indebted to the United States Fish Commission for the publication of Prof. Farlow's "New England Algæ."

It may be said at once that Dr. Reinke's "Atlas" is a success in every way, its level being that of Bornet and Thuret's "Études Phycologiques." From the point of view of *technique*, the plates are splendidly done, and the rest of the publication is worthy of them. This first part contains twenty-five quarto plates, and the text belonging to them consists of descriptions of the Algæ figured and special descriptions of the illustrations. Speaking not merely from an inspection of the book, but from a knowledge of the material of much of it communicated by Dr. Reinke to the British Museum, I do not hesitate to state that every one of these figures has great value to phycologists. They are not mere portraits of Algæ, taken from specimens more or less at haphazard, as is too much the fashion, but they represent faithfully characteristic stages in the development of the organisms in point. What is commonly termed "microscopical detail" fills the "Atlas," and one can hardly imagine it better done. In this portion the author (who has had the assistance of Dr. F. Schütt and P. Kuckuck) deals prominently with the Phæophyceæ, which, it is well known, are his particular study at present. Many of them are types of his own discovery, and generally unknown to workers in this field until this satisfactory introduction to them. Since they are of special importance to our native phycologists as Algæ of the North Sea and Baltic, a list is given of them:—

Halothrix lumbricalis, Kütz., *Symphoricoccus radians*, Rke., *Kjellmania sorifera*, Rke., *Asperococcus echinatus*, Mert., var. *filiformis*, Rke., *Ralfsia verrucosa*, Aresch., *R. clavata*, Carm., *Microspongium gelatinosum*, Rke., *Leptonema fasciculatum*, Rke., var. *uncinatum*, var. *majus*, var. *flagellare*, *Desmotrichum undulatum*, J. Ag., *D. balticum*, Kütz., *D. scopulorum*, Rke., *Scytosiphon pygmæus*, Rke., *Ascocyclus reptans*, Cr., *A. ocellatus*, Kütz., *A. balticus*, Rke., *A. fœcundus*, Strömf., var. *seriatus*, Rke., *A. globosus*, Rke., *Ectocarpus sphæricus*, Derb. et Sol., *E. Stilophoræ*, Cr., *E. repens*, Rke., *E. ovatus*, Kjellm., var. *arachnoideus*, Rke., *Rhodochorton chantransioides*, Rke., *Antithamnion boreale*, Gobi, var. *balticum*, Rke., *Blastophysa rhizopus*, Rke., *Epicladia Flustræ*, Rke., *Cladophora pygmæa*, Rke., *Pringsheimia scutata*, Rke.

It may be anticipated that a fair number of the novelties among these so-called "German Algæ" (the title reminds one of the "Protestant trout") may be found on our own coasts.

It should be mentioned that more systematic detail with reference to many of these is to be found in the author's "Algenflora des Westlichen Ostsee" (Berlin, 1889).

The author very properly calls attention to the fundamental importance of a thorough knowledge of marine Algæ to fishery, since the plant world prepares by its organs of assimilation the food of the animal world in the sea. The German Commission deserve the highest praise for the enlightened view of their functions embodied in this undertaking, and no biologist will grudge the warmest encouragement to Dr. Reinke in his work. It is anticipated that the book, when complete, will contain a hundred plates, with the accompanying text. In these days, when the most unmitigated rubbish frequently comes to us with highly pretentious illustrations, the student has learned to be on his guard against "prepossessing appearances." No *plate manufacture*, however, can produce the welcome impression of weight and importance stamped on this "Atlas," gained to a great extent by the fact that Dr. Schütt and Herr Kuckuck, who have drawn the plates, have given us the work of skilful botanists, and not that of draughtsmen only.

G. M.

OUR BOOK SHELF.

Die mikroskopische Beschaffenheit der Meteoriten erläutert durch photographische Abbildungen. Von G. Tschermak. (Stuttgart: E. Schweizerbart'sche Verlagshandlung [E. Koch], 1883-85.)

Die Structur und Zusammensetzung der Meteoreisen erläutert durch photographische Abbildungen geätzter Schnittflächen. Von A. Brezina und E. Cohen. (Stuttgart: E. Schweizerbart'sche Verlagshandlung [E. Koch], 1886-87.)

Die Meteoritensammlung des k. k. mineralog. Hofkabinetes in Wien. Von A. Brezina. (Wien: Alfred Hölder, 1885.)

THE above three works together provide for the student a rich treasury of information relative to the characters of meteorites. The first two illustrate, by the aid of photography, the structure and composition of the more typical meteoric stones and irons respectively. The work dealing with the meteoric stones is complete in three parts, including 25 large plates, and has been undertaken by Prof. Tschermak, who had charge of the Vienna Collection of Minerals from 1869 to 1877. Of that which relates to the meteoric irons only two parts have as yet appeared, but they comprise no fewer than 24 large plates: it is undertaken jointly by Dr. Brezina, who succeeded Prof. Tschermak in the keepership of the Vienna Collection, and by Prof. E. Cohen, of Greifswald, whose series of micro-photographs of sections of terrestrial minerals and rocks is so well known.

Photography has rarely been applied to a more satisfactory purpose than the multiplication of exact representations either of transparent meteoritic sections, or of etched meteoric irons as seen with the unassisted eye or when magnified by means of the microscope. Meteoritic falls are rarely so large that the market is flooded with